ORIGINAL ARTICLE

Improvement in Timing of Antibiotic Administration by Using a Prophylactic Antibiotic Record Form

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Background/Purpose: To evaluate the effect of a form recording the timing of prophylactic antibiotic administration, antibiotics used, and treatment duration on the proper use of prophylactic antibiotics in patients undergoing four types of operations.

Methods: This was a retrospective study in a 682-bed, university-affiliated, tertiary teaching hospital. Using the form developed, nurse practitioners recorded the timing of prophylactic antibiotic administration, antibiotics used, and treatment duration for patients undergoing three types of clean operations (total hip replacement, total knee replacement, thyroidectomy) and one type of clean-contaminated operation (hemorrhoidectomy). Patient records were identified by chart review after searching the hospital database. A case was defined by a principal or secondary procedure code for the four types of operations. Patients who received therapeutic antibiotics for documented preoperative infection were excluded.

Results: A significant improvement ($p < 0.001$; OR, 33.768; 95% CI, 4.304–264.951) in the use of prophylactic antibiotics was noted between the pre-intervention and intervention periods. Among the three criteria of antibiotic usage, the improvement in the appropriate timing of prophylactic antibiotics was significant ($p < 0.001$; OR, 46.247; 95% CI, 5.891–363). The accuracy of the prophylactic antibiotic form in recording the timing of antibiotic administration, the choice of antibiotics, and the treatment duration was 84.2% (16/19), 89.4% (17/19), and 100% (19/19), respectively.

Conclusion: The prophylactic antibiotic form effectively decreased the inappropriate use of prophylactic antibiotics. Due to its high degree of reliability, this infection control measure can be used as a continuous monitoring system for prophylactic antibiotic use. [*J Formos Med Assoc* 2008;107(3):218–224]

Key Words: antibiotic prophylaxis

One of the milestones of current surgical practice is the use of prophylactic antibiotics, which has dramatically reduced the incidence of postoperative infection.[1] Prophylactic antibiotics are especially effective when given before surgical incision. A large prospective clinical trial found that the period within 2 hours pre-incision was the ideal time to administer prophylactic antibiotics; giving prophylactic antibiotics after the incision was associated with a fourfold increase in surgical site infections.[2] However, despite this evidence, various errors can occur in the use of prophylactic antibiotics, including: inappropriate timing; incorrect antibiotics; inaccurate duration; and inadequate documentation.[3–5] Inappropriate or prolonged antimicrobial prophylaxis increases the risk of

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postoperative infection, adversely affects the microbial ecology within the hospital, and increases the risk of antibiotic resistance.[6]

Many authors have underlined the importance of strict adherence to validated guidelines and have shown improved usage of prophylactic antibiotics after guideline development and implementation.[7] However, even though a Taiwanese guideline for the use of prophylactic preoperative antibiotics was developed in 2004,[8] a retrospective audit conducted to evaluate the usage of prophylactic antibiotics in our institution, the National Taiwan University Hospital, Yun-Lin Branch, in the same year found many instances of inappropriate usage. The most common problem was the inappropriate timing of antibiotic administration; only 7.5% patients were documented to have received prophylactic antibiotics within 2 hours before surgical incision. The second most common problem was the prolonged use of antibiotics (in 16.25% of patients). Thus, in April 2005, the infection control committee of our hospital started to regulate the use of prophylactic antibiotics. This study evaluated the efficacy of the control measure implemented to decrease the inappropriate use of prophylactic antibiotics.

Methods

This retrospective, epidemiological investigation was performed at the National Taiwan University Hospital, Yun-Lin Branch, a 682-bed, university-affiliated, tertiary care teaching hospital. The hospital has three surgical wards. Prophylactic antibiotics are prescribed by attending physicians or residents and given by ward nurses.

In April 2005, a control measure was introduced to reduce the inappropriate usage of prophylactic antibiotics. The surgical team was asked to fill in a *prophylactic antibiotic form* for four types of surgical procedures. The form was introduced by the infectious disease physician and approved by the infection control committee of our institution. Since delayed administration of prophylactic antibiotics and prolonged treatment duration were the main problems identified in 2004, the form was used to record and monitor the timing of the operation, the type of operation, the time when the antibiotics were administered, the antibiotics used, the duration of antibiotic treatment, and the surgeon's name (Figure). The four types of surgical procedures included three with clean wounds (total hip replacement [THR], total knee replacement [TKR], thyroidectomy), and one with a clean-contaminated wound (hemorrhoidectomy). These procedures were selected due to their high volume in our hospital and the fact that there was consensus regarding appropriate antimicrobial prophylaxis. The form was completed by nurse practitioners of the surgical department and collected monthly by the infection control team. The results were reported at the infection control committee meeting held every 2 months; during the meeting, the infectious disease physician further discussed with the surgeons their inappropriate use of prophylactic antibiotics.

Since prophylactic antibiotics may be urgently needed, use of the prophylactic antibiotic form was not mandatory. Thus, the surgical team could prescribe and continue the antibiotics based on their own judgment, whether or not they used the form.

After the control measure was implemented, we retrospectively collected the data regarding prophylactic antibiotic use by conducting a chart review. Patient records were identified by searching the hospital database during the period from April 1 to September 30, 2005. A comparison group was selected from the pre-intervention period from April 1 to September 30, 2004. A case was defined as having the principal or secondary procedure code from the International Classification of Diseases, Ninth Revision, Clinical Modification[9] of THR (81.51), TKR (81.54), thyroidectomy (06.2, 39.4, 39.50, 39.51, 39.52), or hemorrhoidectomy (49.46). Patients who received therapeutic antibiotics due to a documented preoperative infection were excluded.

The main outcome measures included: (1) the proportion of patients who had parenteral antimicrobial prophylaxis initiated within 2 hours

National Taiwan University, Yun-Lin Branch
Prophylactic Antibiotic Record Form

Patient Data
Name: _____ Case number: _____ Bed number: _____

Surgical Type
☐ Total Hip Replacement
☐ Total Knee Replacement
☐ Thyroidectomy
☐ Hemorroidectomy

Infection before operation? ☐ YES ☐ NO

Surgical Date: DD/MMM/YY

Operation: _____ ; **Recorder:** _____

Prophylactic antibiotics administered before incision?
☐ NO ☐ Within 30 minutes ☐ Within 2 hours ☐ Longer than 2 hours

Operation time > 3 hours?
☐ NO ☐ YES (re-administered antibiotics? ☐ YES ☐ NO)

Choice of antibiotics, dosage, route, duration

Antibiotic	Dose, interval	Route	Start date	End date	Total duration
		☐ iv ☐ po			
		☐ iv ☐ po			
		☐ iv ☐ po			
		☐ iv ☐ po			
		☐ iv ☐ po			
		☐ iv ☐ po			

(After this form has been filled in by the surgical department, please send back to the infection control team no later than the 10th of the next month.)

Figure. Prophylactic antibiotic record form.

prior to the surgical incision; (2) the proportion of patients who received a prophylactic antibiotic that was consistent with currently published Taiwanese guidelines;[8] and (3) the proportion of patients whose duration of prophylactic antibiotics was consistent with the currently published regulation of the National Health Insurance Bureau of Taiwan for that type of surgery, which requires one dose for surgery with a clean wound, less than 3 days in clean surgery with implants, and less than 3 days in surgery with a clean-contaminated wound.[10] The prescription of prophylactic antibiotics was regarded as inappropriate if it did not meet any one of the criteria (timing of

Table 1. Evaluation of the criteria for antibiotic prophylaxis practices

Criterion	Evaluation	Definition
Antibiotic choice	Acceptable	If in agreement with guidelines[8]
	Not acceptable	Otherwise
Timing of administration	Acceptable	If antibiotic was injected within 2 hr before incision
	Not acceptable	If antibiotic was injected 2 hr before incision or if antibiotic was injected after incision, or if there was no record of the timing of antibiotic administration
Treatment duration	Acceptable	If it did not exceed 1 dose for clean surgery, or did not exceed 72 hours for clean-contaminated surgery and clean surgery with implants
	Not acceptable	If it exceeded 1 dose for clean surgery or exceeded 72 hours for clean-contaminated surgery and clean surgery with implants[9]

administration, antibiotic choice, treatment duration). The methodology used to evaluate these outcomes is shown in Table 1.

The accuracy of the prophylactic antibiotic form recorded by nurse practitioners was verified by chart review at the same time for the three major outcomes, including the timing of administration, antibiotic choice, and treatment duration.

The results of the surgical patients from April 1 to September 30, 2005 were compared to those treated during the same period in 2004. The proportion was compared using the χ^2 test; in any cells with values < 5, Fisher's exact test was used instead. A p value less than 0.05 was regarded as statistically significant.

Results

Based on the procedure codes, 40 cases were identified from April to September 2004 and 55 were identified from April to September 2005. One case with an anal abscess in 2004 and four (2 with anal abscesses, 2 with septic arthritis) in 2005 were excluded due to documented preoperative infections. Thus, there were 11 cases of THR, 13 of TKR, two of thyroidectomy, and 13 of hemorrhoidectomy in 2004; while in 2005, there were 21 cases of THR, two of TKR, four of thyroidectomy, and 24 hemorrhoidectomy (Table 2).

There was a statistically significant reduction in inappropriate antibiotic prescription from the pre-intervention period (38/39, 97%) to the intervention period (27/51, 54%) ($p < 0.001$; OR, 0.0296; 95% CI, 0.004–0.232). Improvements were significant in the appropriate timing of prophylactic antibiotic administration ($p < 0.001$; OR, 46.247; 95% CI, 5.891–363), while there was only a trend in the improvement of the choice of appropriate antibiotics (87.2% to 92.2%; $p = 0.435$) and in appropriate treatment duration (87.2% to 90.2%; $p = 0.652$) (Table 3).

Table 2. Surgical category in the pre-intervention and intervention periods

Surgical category	Pre-intervention *n/N* (%)	Intervention *n/N* (%)
Total hip replacement	11/39 (28.2)	21/51 (41.1)
Total knee replacement	13/39 (33.3)	2/51 (3.9)
Thyroidectomy	2/39 (5.1)	4/51 (7.8)
Hemorrhoidectomy	13/39 (33.3)	24/51 (47)
Total	39/39 (100)	51/51 (100)

During the pre-intervention period, only 2.6% (1/39) of patients were documented as having received prophylactic antibiotics within 2 hours before the incision; 5% (2/39) of patients received prophylactic antibiotics more than 2 hours before the incision; and the remaining 92% (36/39) of patients had no documentation at all regarding the use of prophylactic antibiotics. After the use of the prophylactic antibiotic form was implemented, 54.9% (28/51) of patients were

Table 3. Comparison between the pre-intervention and intervention periods for antibiotic prophylaxis evaluation criteria in four index surgical procedures

	Pre-intervention *n/N* (%)	Intervention *n/N* (%)	*p*
Inappropriate timing of administration	38/39 (97.4)	23/51 (45.1)	<0.001
Inappropriate choice of antibiotics	5/39 (12.8)	4/51 (7.8)	0.435
Inappropriate treatment duration	5/39 (12.8)	5/51 (9.8)	0.652
Total inappropriate prophylactic antibiotic prescriptions*	38/39 (97.4)	27/51 (52.9)	<0.001

**Prophylactic antibiotic prescription regarded as inappropriate if it was not in the acceptable category in any one of the criterion of timing of administration, antibiotic choice and treatment duration.*

Table 4. Comparison of subjects for whom the prophylactic antibiotic record form was and was not used

	Record form used *n/N* (%)	Record form not used *n/N* (%)	*p*
Inappropriate timing of administration	3/19 (15.7)	20/32 (62.5)	0.001
Inappropriate choice of antibiotics	4/19 (21)	0/32 (0)	0.004
Inappropriate treatment duration	1/19 (5.2)	4/32 (12.5)	0.401
Total inappropriate prophylactic antibiotics prescriptions*	4/19 (21)	20/32 (62.5)	0.004

**Prophylactic antibiotic prescription regarded as inappropriate if it was not in the acceptable category in any one of the criterion of timing of administration, antibiotic choice and treatment duration.*

Table 5. Comparison of subjects for whom the prophylactic antibiotic record form was and was not used in the intervention period versus the pre-intervention period

	Pre-intervention *n/N* (%)	Intervention			
		Record form used		Record form not used	
		n/N (%)	*p*	*n/N* (%)	*p*
Total inappropriate prophylactic antibiotic prescriptions	38/39 (97.4)	4/19 (21)	<0.001*	20/32 (62.5)	<0.001†

**Comparison of inappropriate prophylactic antibiotic prescription rate of subjects for whom the prophylactic antibiotic record form was used in the intervention period versus pre-intervention period; †comparison of inappropriate prophylactic antibiotic prescription rate of subjects for whom the prophylactic antibiotic record form was not used in the intervention period versus pre-intervention period.*

documented as having received prophylactic antibiotics within 2 hours before the incision; 37% (19/51) of patients had no documentation; and 7.8% (4/51) of patients received antibiotics more than 2 hours before the incision.

During the intervention period, the prophylactic antibiotic form was available for 19 cases (19/51, 37%). There was a statistically significant improvement in prophylactic antibiotic utilization ($p = 0.004$; OR, 6.25; 95% CI, 1.67–23.2) in the patients with a record form compared to those for whom the form was not available (Table 4). However, compared to the pre-intervention period, an improvement was seen in all patients in the intervention period, not only in those for whom the prophylactic antibiotic form was used. Among the 19 patients in whom the form was used, the proportion of inappropriate prophylactic antibiotic use decreased from 97.4% to 21% ($p < 0.001$; OR, 142; 95% CI, 14.7–1380); among the 32 patients in whom the form was not used, the proportion also decreased from 97.4% to 62.5% ($p < 0.001$; OR, 22.8; 95% CI, 2.7–188) (Table 5).

The accuracy of the documentation by nurse practitioners was verified in the 19 cases for whom the prophylactic antibiotic form was available.

The accuracy of documenting the timing of antibiotic administration, choice of antibiotics, and treatment duration was 84.2% (16/19), 89.4% (17/19), and 100% (19/19), respectively.

Discussion

Though it has been well documented that prophylactic antibiotics reduce the probability of postoperative infection,[1] there are still many instances of inappropriate use of prophylactic antibiotics in clinical practice.[3–5] This study was designed to evaluate the effect of an infection control program. The *prophylactic antibiotic form*, which was implemented in April 2005, was developed to decrease the inappropriate use of prophylactic antibiotics. The results revealed a statistically significant improvement ($p < 0.001$; OR, 33.768; 95% CI, 4.304–264.951) in the use of prophylactic antibiotics during the intervention period (April to September 2005) compared to the pre-intervention period (April to September 2004).

The benefit was most obvious in the timing of antibiotic administration. This improvement may have been the result of improved documentation, improved timing of administration, or both. During the pre-intervention period, 92% (36/39) of patients had no documentation of the timing of prophylactic antibiotic administration; during the intervention period, there was poor documentation, in only 37% (19/51) of patients. If those patients without documentation were excluded, the proper timing of antibiotic administration also improved from 33.3% (1/3) in the pre-intervention period to 87.5% (28/32) in the intervention period. Thus, the prophylactic antibiotic form not only emphasized the importance of the timing of antibiotic administration but also provided a method to document and monitor the use of prophylactic antibiotics.

The improvement in the timing of antibiotic administration was more prominent than the improvement in antibiotic selection and treatment duration. The difference may be due to the fact that the prophylactic antibiotic form was filled in by nurse practitioners rather than surgeons, and the message of this infection control program might have been transmitted more effectively to the nurses who were in charge of antibiotic administration. The different rates of improvement might imply a need for control measures that impact directly on the surgeons in order to improve the choice and duration of prophylactic antibiotics.

Although the prophylactic antibiotic form was used infrequently in the intervention period, a decrease in inappropriate prophylactic antibiotic usage was noted for both patients with the record form and those without. This implied that implementation of the program itself may have enhanced the staff's understanding of the importance of prophylactic antibiotics. Furthermore, realizing that the use of prophylactic antibiotics was being monitored improved the use of prophylactic antibiotics, whether or not the prophylactic antibiotic form was used.

In addition to the improvement in the use of appropriate antibiotics, the prophylactic antibiotic form, due to its reliability and accuracy, can also facilitate continuous monitoring of antimicrobial utilization.

A limitation of the study is that there may have been changes over time that were unrelated to the intervention. However, during the study period, the number of patients admitted for operations remained stable at about 345 cases per month, and there were no additional teaching activities that dealt with prophylactic antibiotic usage during the intervention period. The workflow of prescribing and administration of prophylactic antibiotics also did not change. Furthermore, during the same intervention period from April to September 2005, patients with record forms had received more appropriate prophylactic antibiotics than patients without record forms ($p = 0.004$; OR, 6.25; 95% CI, 1.67–23.2). This shows that the improvement in the use of prophylactic antibiotics was mainly due to the control measure itself rather than to other confounding factors.

In conclusion, the prophylactic antibiotic form was shown to be an efficient control measure that

decreased the inappropriate usage of prophylactic antibiotics, especially the timing of prophylactic antibiotic administration. This antibiotic form can also be used as a continuous monitoring system of prophylactic antibiotic usage due to the high accuracy of the nurse practitioners' documentation. Other control measures that target surgeons should be considered in order to improve their prescription of prophylactic antibiotics, including the choice of antibiotics and treatment duration.

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